Roadside Safety Review

by Rich Peter

July, 2001

Inside this Issue

Division of Engineering Services, Materials Engineering and Testing Services, Roadside Safety Technology Branch

Recent Roadside Safety Developments

As in previous editions, this review provides Caltrans staff with an update on the latest developments in roadside safety hardware. The April and August 2000 editions discussed the role of the Highway Safety Features New Products Committee (HSFNPC) in evaluating new roadside safety hardware. They also summarized FHWA requirements for compliance with National Cooperative Highway Research Program (NCHRP) Report 350 crash testing criteria. Finally, these issues described current Caltrans roadside safety research and proprietary and non-proprietary roadside safety devices that have been evaluated for use on the state highway system.

The July edition of *Roadside Safety Review* continues coverage of ongoing Caltrans research and of roadside safety hardware that is being evaluated or that has recently been approved for use by the Department. Any questions or suggestions regarding past or current news items may be directed to Rich Peter at (916) 227-7257 (Calnet 498-7257) or rich_peter@dot.ca.gov.

Caltrans Approves New Products

Since the August 2000 edition of this review was published, the Traffic Operations Program has approved several new roadside safety products for use on the state highway system. These include:

V-Loc Sign Support System - This sign support consists of a diamond-shaped socket that may be driven into the earth or cast in concrete. A 51-mm (2-inch) square tubular steel sign post can be placed in this socket and then secured with a small, V-shaped steel wedge. Installing a post in this sign support is quick and simple, and the sign support can be reused after some lower-speed hits. This device received operational approval.

The QuadGuard Family – All members of the QuadGuard "family" of products that had previously received experimental approval from Caltrans now have full operational approval. This includes the standard QuadGuard, the QuadGuard LMC and the QuadGuard Elite. These models come in various widths ranging from 610 mm (24 inches) up to 2290 mm (90 inches). Each model also comes in various

Please see Caltrans Approvals, *pg.2*

Caltrans Approvals

Continued from pg. 1

lengths to accommodate different vehicle impact speeds. However, with one exception, Caltrans has approved only those models that have been designed and crash tested for impact speeds of 100 km/h (i.e., NCHRP Report 350 test level 3, or TL-3). QuadGuard models designed for vehicle impact speeds other than 100 km/h should not be used on the state highway system because they generally have not been crash tested.

The one exception, described in the August 2000 R eview, is the QuadGuard TL-2. This system is very similar to the standard QuadGuard except that it is significantly shorter and is designed for lower-speed conditions (70 km/h). It has been successfully crash tested at NCHRP Report 350 test level 2 (TL-2) and has full Caltrans operational approval for selective use on roadways with prevailing speeds of approximately 70 km/h or less. Because of these speed limitations, this device is especially appropriate for use by local transportation agencies.

HBA Posts for ET-2000 - The ET-2000 end treatment is operationally approved and has been used on state highways for several years. The current version of this device features eight wood posts. The four upstream posts are set in soil tubes and the four downstream posts are embedded directly in the earth. When a vehicle strikes the end of an ET-2000 at an angle of approximately zero degrees, the impact head slides down the W-beam rail while the rail is deformed and extruded through the side of the impact head. The wood posts are progressively broken off as the head moves down-stream.

Operational approval of the ET-2000 has recently been extended to include a version with hinged, breakaway (HBA) posts. These posts are comprised of W150x13 steel beam, hinged just above ground level. The HBA version of the ET-2000 performs exactly the same as the wood post version, except that when an impacting vehicle pushes the W-beam down the rail, no posts are broken off. Instead, a bolt at each post hinge shears off and the top portion of each steel post pivots down to the ground. This simplifies repair of the device, since many or even all of the top portions of the steel posts can simply be pulled upright by hand and new shear bolts installed.

TrafFix Scorpion TMA - This truck-mounted attenuator (TMA), manufactured by TrafFix Devices, Inc., is composed of an aluminum frame and aluminum cartridges that crush upon impact to absorb energy. The Scorpion is available in both TL-2 (70 km/h) and TL-3 (100 km/h) versions. The Scorpion performed well in the crash tests, even passing optional tests involving angled and offset impacts to the rear of the device. This TMA is equipped with a hydraulic system that enables the operator to raise and reposition the device for ease of transport. The Scorpion received operational approval.

Absorb 350 – The Absorb 350 is a crash cushion comprised of water-filled plastic segments 900-mm (36-in) long that are connected with hinges. This crash cushion can be used to protect the ends of portable concrete barrier such as K-rail. However, it is manufactured by Barrier Systems, Inc. specifically for use with that firm's Quickchange Moveable Barrier and Reactive Tension System Barriers (see "Quickchange Moveable Barrier" below). This crash cushion is a gating, non-redirectional design. Consequently, impacting vehicles can go through or over the device and sufficient runout room must be provided behind it. The Absorb 350 has experimental approval.

Ericsson Signpost Foundation – This foundation, produced by Ericsson Manufacturing, consists of a 37-kg (81-lb) block of concrete in the shape of a truncated pyramid with a square tubular steel sleeve embedded in the top. Like the V-Loc Sign Support System, the Ericsson Signpost Foundation accommodates 51-mm (2-in) square tubular signposts, and can be reused after low-speed hits.

Quickchange Moveable Barrier – The Quickchange Moveable Barrier (QMB) is comprised of one-meter long concrete barrier segments joined by hinged connections. In cross-section, these segments bear some resemblance to K-rail except that they have a T-shaped top. This feature enables specialized transfer machinery to pick up the barrier and move it laterally up to one lane width in a single pass.

Rapid movement of this barrier makes it ideal for variable lane closures during construction or for operating reversible lanes to handle peak traffic flows. The QMB has been used successfully by Caltrans in the past for traffic control during construction and it is currently used for reversible lane operations on the Coronado Bridge in San Diego. Because of Caltrans' past experience with the QMB, it has received operational approval.

Linear SRT-350 – The SRT-350, manufactured by Trinity Industries, has been a standard Caltrans guardrail end treatment for several years. In 1999, the Department approved a modified version of the SRT-350 that featured fewer posts (eight instead of nine), variable flare lengths and offsets, and several other minor changes. In a continuing effort to simplify the design of this end treatment, Trinity Industries has developed the Linear SRT-350. This device uses only six posts (two of which are HBA posts) and a straight flare with a 1.2-m offset. The Linear SRT has received operational approval.

GPLink Barrier – An aesthetic

GPLink Barrier

Please see Caltrans Approvals, *pg. 3*

Caltrans Approvals

Continued from pg. 2

alternative to the K-rail portable concrete barrier, the GPLink barrier is a Swedish design that features vertical sides with V-shaped horizontal grooves running the length of each 6-m segment. Made of steel-reinforced concrete, each GPLink segment has a mass of 2800 kg, a height of 870 mm and a width of 240 mm. Segments are joined at each end with steel pins and connecting bars. Since the GPLink barrier deflects approximately 80% more than the standard K-rail when hit, it received experimental approval for use only in locations where such deflections are tolerable.

Sedan Impacting Diagonal Rib Texture

Alternative Barrier Textures Evaluated

The Roadside Safety Technology Branch (RSTB) has commenced crash testing a series of barrier textures. The objective of this research is to develop guidelines for selecting barrier textures that ensure these textures won't have significant adverse effects on barrier crashworthiness.

The RSTB is using a Type 60G barrier at the Caltrans Dynamic Test Facility in West Sacramento for these tests. Plastic formliners, plywood and other materials are used to construct forms along the face of the barrier and concrete is placed between the forms and the barrier to create the textured test panels. Once a test panel has cured, the branch conducts crash tests to determine the effect of the individual texture on the performance of the barrier. After each panel is tested, it is removed and a new panel is constructed which features a different texture.

Pickup Impacting Cobble Texture

The first texture to be tested was the "cobble" pattern. This resembled large, rounded cobbles set in mortar with an average relief of 63 mm. Because of the high relief of this texture, it was considered to be a worst-case design from the standpoint of vehicle snagging.

In fact, the front wheel of the pickup truck snagged quite badly in the cobble test, forcing the wheel back to the extent that the driver's door was pushed partway into the space that would have been occupied by the driver. The test was consequently determined to be a failure. The cobble-textured face of the wall incurred no damage other than some minor scrape marks.

The second texture tested was selected

Please see Textured Barriers, *pg. 4*

Textured Barriers

Continued from pg. 3

to evaluate the effect of an upward-angled design on the trajectory of the test vehicle. It consisted of a 25-mm wide by 25-mm deep, fluted rib pattern that sloped upward from the roadway at an angle of 45 degrees.

This test was also a failure. The subcompact sedan used in the test readily climbed up the face of the barrier and rolled over. In addition, the ribs on the barrier face were significantly damaged where the vehicle made contact. Even if the test vehicle had been smoothly redirected, the ribbed texture would probably be unsatisfactory because it would be difficult to maintain. For this reason, no additional ribbed textures were tested.

The third texture to be evaluated was the "mission arch." This consisted of a series of arches 305-mm tall by 305-mm wide, recessed 25 mm into the concrete surface. The edges of the arches were beveled at a 45-degree angle to minimize snagging potential. The area within the arches had a "heavy sandblast" texture while the remainder of the barrier surface had a "light sandblast" surface to provide more visual contrast.

The mission arch performed well in the crash test. Although the subcompact sedan used in the test incurred more body damage than if it had impacted a smooth concrete barrier, there was no significant occupant compartment deformation and the test was determined to be successful.

In late June, the RSTB conducted testing on a "horizontal reveal" pattern. This consists of a horizontal band of texture above a smoother lower band. For this test, the texture chosen for

Mission Arch Pattern

the reveal was the cobble pattern that had been evaluated in earlier testing. The lower 610 mm of the barrier was a relatively smooth "light sandblast" texture. Since this lower band had little wheel snagging potential, the hypothesis was that even an aggressive texture such as the cobble pattern in the horizontal reveal would be acceptable. Test results confirmed this hypothesis. Occupant compartment deformation was minor and all other applicable testing criteria were met. It was concluded that if the lower 610 mm of a barrier face is smooth, a wide range of textures may be used above that lower band with no significant adverse effects on barrier crashworthiness.

The next pattern to be tested will be the "dry stack". This pattern simulates a low relief, cut stone wall with narrow joints between the stones. Testing is

Please see Textured Barriers, *pg. 5*

Horizontal Reveal with Cobble Pattern

Textured Barriers

Continued from pg. 4

Currently scheduled for late July.

Based on testing completed to date, it is likely that guidelines for selecting barrier textures will include the following:

1. High-relief textures extending to ground level are unacceptable.
2. Textures featuring relatively thin ribs or ridges are undesirable because they are readily damaged by vehicle impacts.
3. Textures with upward sloping relief at wheel height should be avoided since it promoted vehicle climbing and potential rollover.
4. Shallow-relief (inset 25-mm or less) geometric shapes with beveled or chamfered edges are acceptable.
5. Roughened concrete textures ranging from light to heavy "sandblast" surfaces perform nearly as well as smooth concrete in vehicle impacts.
6. Provided that the lower 610 mm of a barrier face is relatively smooth, a wide variety of textures may be used above the 610-mm level.

Additions and further refinements to these findings will be made as testing progresses.

"Dry Stack" Pattern

Implementation Nears for New Caltrans Designs

Type 60K Portable Concrete Barrier

All crash testing of the Type 60K barrier has been completed and it has been accepted for use on the National Highway System by FHWA. The plans and specifications for this barrier are nearing completion and it should be available for use later this summer.

This barrier has a single-slope face on each side and is comprised of reinforced concrete segments 914-mm high and 3.7-m in length, connected with two sets of pins through metal bars at each end. The Division of Traffic Operations is currently developing guidelines for the use of the Type 60K. Because this new barrier takes more time to assemble and disassemble than the standard K-rail barrier, it is unlikely that the Type 60K will be used extensively as a short-term work zone barrier. However, its superior crash performance will likely make the 60K a better choice for longer-term applications.

Type 732S Bridge Rail

The Type 732S is a steel version of the Type 732 concrete bridge rail and was developed by the consulting firm T.Y. Lin for use on the new east span of the San Francisco–Oakland Bay Bridge (SFOBB). The Type 732S is significantly lighter than the Type 732, which offers an important advantage on the suspension portion of the SFOBB east span.

The 732S rail was crash tested at the Caltrans Dynamic Test Facility using 2000-kg and 8000-kg trucks. The test vehicles were smoothly redirected and the rail met all applicable crash testing criteria. To replicate the proposed design of the SFOBB span on which this rail will be used, the test article was bolted on the edge of a simulated steel orthotropic bridge deck.

FHWA accepted the rail for use on the National Highway System. Once T.Y. Lin completes the final plans and specifications for this rail, it will be available for use on other Caltrans structures as conditions warrant.

Guardrail to Bridge Rail Transition

The RSTB has completed the crash testing of the guardrail to bridge rail transition. All tests on this newest transition design were successful and it has been accepted by FHWA.

This transition is designed to connect flexible W-beam rail to rigid concrete bridge rail. To preclude snagging and/or rollover when a vehicle impacts the transition, the transition gradually increases in stiffness as it approaches the concrete rail to which it connects. During testing, the transition smoothly redirected 2000-kg and 8000-kg trucks.

Headquarters Traffic Operations is overseeing the preparation of the plans and specifications for the transition, and these should be available this summer.